ENGINEERING ANALYSIS

OF

SEWAGE TREATMENT AT WATERLOO

PREPARED BY

THE DIVISION OF PLANT OPERATIONS

ONTARIO WATER RESOURCES COMMISSION

MARCH 1, 1962

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WATERLOO SEWAGE TREATMENT PLANT

BASIS OF DESIGN (used by Proctor & Redfern - Consulting Engineers)

Stage 1 - 4 MGD

Stage 2 - 6 MGD

Stage 3 - 8 MGD

Basic Design Data, Stage 1

Average 12 hour flow = 4 MGD

Maximum 12 hour flow = 5.6 MGD

Raw Sewage Strength BOD = 300 ppm

SS = 270 ppm

Grit Removal

Existing detritor = 12 ft. x 12 ft.

Settling area per MGD = $\frac{144}{5.6} = \frac{144}{6.7}$ = 21.4 sq. ft. per MGD US Gallons

Primary Clarification

Existing primary tank one - 75 ft. diameter x 10'-6" depth.

Surface area = 4420 sq. ft.

Rise rate = 1087 US Gallons per sq. ft. per day.

Detention period = 1.7 hours.

Weir loading = 20,400 USGPD per lineal foot.

Aeration Tanks

Assumed reduction in BOD = 25%.

BOD load on aeration tanks = 225 ppm.

∴ Total BOD load = 9,000 lbs. per day.

Volume required = 240,000 cu. ft. = 1,495,000 gallons.

Aeration period - Sewage only 9 hrs. with 25% return sludge 7.2 hours.

Aeration Tanks - Continued

Air requirements

- assume 600 cu. ft. per lb. BOD removed

∴ Provide 3750 cu. ft. per minute at 9 psi.

Provide 100% standby ∴ use 2 blowers @ 3750 CFPM

Final Tanks

Minimum requirement = 600 gals. per sq. ft. per day.

Area required = 7600 sq. ft.

Provide 2 clarifiers @ 65 ft. diameter each = 6640 sq. ft.

Detention period at 4 MGD and 10 ft. SWD = 2.5 hours.

Weir rate = 9800 GPD per foot.

Detention period with 25% return sludge = 2 hours.

Weir rate = 7850 GPD per foot.

Digesters

Required capacity at 60°F. = 17 cu. ft. per pound of volatile solids per day.

∴ Volatile solids to be digested = 7175 pounds per day.

∴ Digester capacity at 60° F. = 122,000 cu. ft.

At 95° F. capacity = 55,000 cu. ft.

Existing digesters have 50 ft. diameter x 20' SWD = 78,500 cu. ft.

Sludge Filtration

Assume 5 day, 6½ hour operation

Sludge to be dewatered = 2210 lbs. per hour fresh sludge.

Digested sludge to be filtered = 1473 lbs. per hour.

Sludge Filtration - Continued

Recommended filter rate = 5 lbs. per sq. ft. per hour.

Filter area required = 320 sq. ft.

A 10 ft. dia. x 12 ft. long coilfilter was provided.

REPORT ON THE OPERATION OF THE

WATERLOO SEWAGE TREATMENT PLANT - 58-S-22

FLOW RECORDS

Prior to the design of the extension, the consulting engineers analyzed flow charts taken at the existing plant over the previous two years. From these, it was determined that the pertinent flow data entering the plant at the time of engineering the extension were as follows:

1. The average daily 24 hour flow for all days including Saturday and Sunday was 1.58 MGD.
2. The average daily 24 hour flow for all working days was 1.83 MGD.
3. The average daily 24 hour flow for all Saturdays and Sundays over the year was 1.08 MGD.

Since 1960, the following flow figures have been collected:

1. The average daily 24 hour flow for all days including Saturday and Sunday was 1.9 MGD.
2. The average daily 24 hour flow for all working days was 2.3 MGD.
3. The average daily 24 hour flow for all Saturdays and Sundays was 1.5 MGD.

The above comparison of figures between the 2 years prior to the design of the plant and the 2 years after construction shows that all the flows have increased by approximately 0.5 MGD. This increase is probably entirely due to the increase in population from 15,276 to 20,562.

Field investigations by the consultants determined that Carlings and Seagrams contributed a waste flow to the sanitary sewers of 0.54 MGD. Hence, it was estimated that the average daily flow over 24 hours for all working days, excluding the waste flows from the brewery and the distillery, was 1.29 MGD. Of this flow, 1.08 MGD was contributed by domestic use of water and infiltration, the balance (0.21 MGD) being contributed by industries other than the distillery and the brewery.

Over the period of study, the population of Waterloo was 15,273 persons. Thus, the domestic flow and infiltration contribution (excluding industry) on a per capita basis was 71 gallons per day. The corresponding flow from industry, excluding the brewery and the distillery, was 14 gallons per capita per day.

Reports have been prepared by the OWRC on Carlings and Seagrams and are attached to and form a part of this report.

FLOW RECORDS 1960

MONTH	ABSOLUTE MAXIMUM	AVG. MAX.	AVG. DAILY FLOW	TOTAL MONTHLY FLOW	AVG. DAILY WEEKDAY FLOW	AVG. DAILY WEEKEND FLOW
JAN.	4.3	3.3	2.2	64.8	2.5	1.9
FEB.	4.2	3.0	1.9	52.5	2.2	1.4
MAR.	5.2	3.5	2.4	70.5	2.6	1.6
APR.	5.2	4.2	3.1	81.6	3.3	2.6
MAY	4.6	3.7	2.7	78.1	3.0	2.1
JUNE	5.4	3.6	2.6	77.2	2.8	1.7
JULY	5.0	3.2	1.9	53.2	2.3	1.3
AUG.	4.8	3.0	1.9	58.0	2.5	1.4
SEPT.	4.6	2.9	1.6	45.5	2.0	1.2
OCT.	4.1	3.0	1.6	50.5	1.9	1.2
NOV.	4.2	2.9	---	----	---	---
DEC.	* ---	---	---	----	---	---
AVG.	4.7	3.2	2.2	57.5	2.5	1.6
				(631.9) TOTAL		

* Meter away for repairs.

FLOW RECORDS 1961

MONTH	ABSOLUTE MAXIMUM	AVG. MAX.	AVG. DAILY FLOW	TOTAL MONTHLY FLOW	AVG. DAILY WEEKDAY FLOW	AVG. DAILY WEEKEND FLOW
JAN.	---	---	---	----	---	---
FEB.	4.3	2.5	1.8	49.6	1.9	1.4
MAR.	3.8	2.7	1.9	57.6	2.0	1.5
APR.	3.3	2.4	2.0	59.0	2.1	1.6
MAY	3.8	2.9	1.9	59.2	2.1	1.4
JUNE	4.2	3.1	1.9	56.5	2.1	1.3
JULY	4.4	2.9	1.6	50.8	1.8	1.2
AUG.	4.4	3.0	1.7	52.1	1.9	1.1
SEPT.	4.3	2.9	1.7	51.7	1.9	1.1
OCT.	3.7	2.8	1.5	47.6	1.7	1.2
NOV.	4.3	3.0	1.7	53.1	2.2	1.3
DEC.	4.4	2.9	1.8	56.6	2.0	1.4
AVG.	4.1	2.8	1.8	54.0	2.0	1.3
				(593.8) TOTAL		

It has been estimated that the total daily volume of waste from Carlings brewery is 850,000 GPD(1).

(1) See Appendix

PART A -

RAW SEWAGE

Values for 1960 (Weekly composites plus grab samples)

TABLE I

	BOD	DATE (1960)
Average	578 ppm	
Maximum	2600 ppm	August 27
Minimum	205 ppm	August 8
	Suspended Solids	
Average	560 ppm	
Maximum	3876 ppm	August 27
Minimum	116 ppm	November 3

Values for 1961 (Weekly composites plus grab samples)

TABLE II

	BOD	DATE (1961)
Average	585 ppm	
Maximum	2450 ppm	February 22
Minimum	120 ppm	February 25
	Suspended Solids	
Average	423 ppm	
Maximum	944 ppm	July 27
Minimum	158 ppm	February 25

Values for October and November (daily composite samples)

TABLE III

	BOD	DATE (1961)
Average	600 ppm	
Maximum	1400 ppm	November 1
Minimum	125 ppm	November 5
	Suspended Solids	
Average	391 ppm	
Maximum	866 ppm	November 10
Minimum	172 ppm	November 5

TABLE IV

DAY	AVG. BOD	FREE AMMONIA	AVG. SUSPENDED SOLIDS
Sunday	157 ppm	41.3 ppm	202 ppm
Monday	452 ppm	21.5 ppm	408 ppm
Tuesday	624 ppm	19.1 ppm	372 ppm
Wednesday	760 ppm	18.7 ppm	370 ppm
Thursday	638 ppm	47.2 ppm	394 ppm
Friday	798 ppm	22.3 ppm	523 ppm
Saturday	580 ppm	29.0 ppm	474 ppm
Overall	600 ppm	28.3 ppm	391 ppm

Average for Monday to Saturday
BOD = 642 ppm

Suspended Solids = 424 ppm
NH_3 = 26.3 ppm

Avg. Monday - Friday
BOD - 654 ppm

S. S. - 415 ppm
NH_3 - 25.7 ppm

REMARKS

1. All results for 1960 and 1961 (i.e. Tables I and II) include both composite and grab samples. Tables III and IV are tabulated using only 8 hour composite samples.
2. A comparison of Tables I, II and III shows that the BOD of the raw sewage is increasing. There has been a gradual increase from the 1960 average of 585 ppm to 600 ppm average for the extensive sampling in October and November. It should be noted that the samples in 1960 and 1961 (Tables I and II) were usually taken on Thursdays. In comparing these averages with Table IV, it can be seen that the increase is more marked, as the average for Thursday in October and November was 638 ppm.
3. The figures for Saturday, while slightly below the overall average BOD of 600 ppm, are still quite high. The suspended solids are definitely higher at 474 ppm as compared to the weekly average of 391 ppm. This would suggest that there are clean-ups being carried out at the brewery. Also, the flow of sewage would be somewhat lower and should be considered.
4. When combined with the flow figures, the values for Sunday will give a good estimate of the strength of the strictly domestic sewage from the city. The ammonia content at 41.3 ppm is more than ample to meet the needs of the biological process on Sunday.

5. With regard to clean-ups, the values for Friday should be considered. The figures for both BOD and suspended solids are the highest for the week and this clearly indicates an extensive clean-up at the end of the week.
6. No mention has been made of pH of the raw sewage, but it definitely is a factor to be considered. Extreme values of pH are experienced whenever there are shock loads received at the plant. Also, the change from a very high to a very low pH (or vice versa) occurs rather quickly. For example, on October 27, 1961, Friday, the pH (recorded at the STP) changed from 3.2 at 3:15 PM to 11.7 at 4:30 PM; a time lapse of only 45 minutes.
7. Judging from Table IV, the best day to get the most representative composite sample is Thursday, the day presently being used for weekly composite sampling. The figures for Thursday are slightly higher in both BOD and suspended solids.
8. Bearing in mind the suggested ratio of 20 to 1 for BOD to nitrogen, the overall figures are slightly more at 21.2 to 1. It would be desirable to maintain the ratio at about 18 to 1. It should be noted that in getting the average value for ammonia (note figures are for ammonia nitrogen as N) one extreme value of 155 ppm (Thursday, October 19) was included and this increased the overall average and also the average for Thursday. Excluding the Thursday average, the ratio for the other four days

becomes 32.3 to 1, indicating a definite deficiency of nitrogen in the raw sewage. Granted, the values for Sunday are in excess of the ratio, but the amount in pounds would not be enough to make up the deficiency for the rest of the week as the flow is much lower.

9. From Tables I and II, it can be seen that the numerous shock loads received at the STP are quite strong. Also, it has previously been mentioned that there have been many extreme values of pH. It would appear that the primary concern is to neutralize the shock loads entering the plant. The ideal situation is to have a sewage entering the plant which is as constant in volume and strength as possible.

TABLE V

PRIMARY EFFLUENT

VALUES FOR 1960

Weekly Composite Plus Grab Samples

	BOD	DATE (1960)
Average	401 ppm	
Maximum	800 ppm	October 27
Minimum	88 ppm	August 15
	Suspended Solids	
Average	560 ppm	
Maximum	840 ppm	October 27
Minimum	42 ppm	August 2

TABLE VI

PRIMARY EFFLUENT

VALUES FOR 1961

Weekly Composite Plus Grab Samples

	BOD	DATE (1961)
Average	660 ppm	
Maximum	1750 ppm	November 10
Minimum	135 ppm	September 10
	Suspended Solids	
Average	792 ppm	
Maximum	4058 ppm	February 14
Minimum	94 ppm	March 2

TABLE VII

PRIMARY EFFLUENT

DAILY COMPOSITE SAMPLES

	BOD	DATE (1961)
Average	961 ppm	
Maximum	1750 ppm	November 10
Minimum	130 ppm	November 26
	Suspended Solids	
Average	1300 ppm	
Maximum	2296 ppm	November 5
Minimum	178 ppm	November 26

1. A comparison of Tables V, VI and VII shows that the operation of the primary tank has become very inefficient. It has reached the point where there is no BOD or suspended solids removal at all, due to a continual bulking condition. The build-up of sludge in the primary clarifier has resulted in too long a retention period of the sludge creating an anaerobic condition. The accumulation of the anaerobic sludge has reached a point where the BOD of the primary effluent has averaged higher than the BOD of the raw sewage entering the primary clarifier (comparison of Tables III and VII).

2. No attempt has been made to correlate the average BOD values for each day of the week during October and November, 1961, since the values were high for all days. As mentioned previously, the bulking was continuous and no set pattern could be established for the times when bulking was the worst.
3. Comparing Tables I and V (values for 1960) at a time when it can be assumed that there was very little sludge accumulation in the primary, it can be seen that there was a removal of BOD in the order of 30.6 percent. However, in 1961, the BOD increased through the primary clarifier.

Availability of Ammonia

Since most of the NH_3 present is in solution in the raw sewage, little or none of the NH_3 is removed in the primary clarifier. Therefore, one can expect the average NH_3 recorded in Table IV to be available in the aeration units. Therefore, if we assume an average BOD of 650 ppm for the raw, and provided we can get 20 % removal in the primary, then the average BOD of the primary effluent will be 520 ppm. Referring to Table IV, the average NH_3 of the raw sewage was 28.3 ppm, so this appears to be sufficient. However, on some days it was much lower, that is, about 26 ppm NH_3 is necessary on the average day but on some days the BOD averaged higher and the NH_3 lower. It would appear that it would be necessary to add ammonia from Monday to Friday and possibly some on Saturday.

Addition of Ammonia

Tests of ammonia feeding were started in September and during the first few weeks the results were very good. Settling was fast and produced a sparkling effluent. This was true even though the primary was continually bulking. The process was upset only when severe shock loads entered the plant. Continual shock loads prevented the formation of a good stable activated sludge.

Samples taken of the raw sewage showd a dissolved oxygen of 2 ppm so the sewage is not septic when it arrives at the plant. In passage through the primary, the dissolved oxygen was zero or slightly more at about 0.1 or 0.2 ppm. The dissolved oxygen in the aeration tanks was also very low at times, being less than 1 ppm. At the time when tests were started, the dissolved oxygen in the aeration tanks reached a peak of 3.5 ppm. From Table IV, it can be seen that ammonia feeding will probably be necessary during weekdays. The BOD to N ratio was considerably lower than the 20 to 1 ratio recommended on Monday, Tuesday, Wednesday and Friday. The average for Thursday was higher due to one very high value so it would probably be necessary to add free ammonia on that day also.

The mixed liquor has only on rare occasions shown good settling characteristics and, for this reason, it may be necessary to add other nutrients (iron and alum salts) in order to produce a heavier sludge. On the other hand, if the primary sludge is not anaerobic, the addition of free ammonia might result in the

formation of a heavier sludge. This appeared to be the case when the ammonia feeding was initially started.

pH VARIATIONS

The raw sewage at Waterloo exhibits an extreme fluctuation in pH. This pH variation is very detrimental to the activated sludge in the aeration tank, affects the addition of coagulants in sludge filtering, and may have some harmful effects on digester operation.

SEAGRAMS DISTILLERY

ALKALINE WASTES

The most significant feature of the wastes from Seagrams is the discharge of batches of alkaline waste to the sewer. The total quantity of spent caustic in solution wasted is considerably less than the 1740 lbs. per week used for boilups and water conditioner regeneration. However, the manner in which the caustic is wasted, that is, in batches over periods of one-half to one hour, suggests that it is responsible for some of the periodic conditions of high pH of the sewage plant influent.

ACID WASTES

The discharge of batches of acidic wastes to the sewer has not been shown to disrupt the sewage plant operations, but the samples of thesewastes indicate that the pH and acidity of these wastes are capable of causing serious corrosion to concrete sewers.

CARLINGS BREWERY

ALKALINE WASTES

Alkaline effluents from the bottling operation and weekly cleanup appear to be the chief sources of the high pH wastes from Carlings. It has been estimated that approximately 4,000 pounds per week are used in the bottling and cleanup and this eventually all reaches the sanitary sewers.

ACID WASTES

The cation deionizer units are regenerated with sulphuric acid but this effluent is automatically neutralized with a sodium hydroxide solution.

The mechanical set-up for neutralizing the raw sewage at the Waterloo plant could cost approximately $3,000. In addition, it is estimated that 1¼ to 1½ tons of sulphuric acid or 12 to 15 tons of pickle liquor would be required each week under the worst conditions.

COSTS

Hauling charges for pickle liquor = $45 per 2,000 gallons

Weekly requirement = 24,000 to 30,000 lbs.

∴ Weekly cost = $45 x 1.2 = $54.00

Cost of sulphuric acid = $45 per week

PART B

PRIMARY SEDIMENTATION

In the original design, it was found that the existing sedimentation tank was too small to satisfy conventional design standards, but instead of providing further primary capacity, the engineers determined that it was more economical to accept the lower efficiency of the existing primary tank and to accommodate the higher loadings at the secondary treatment facilities.

The existing primary tank is a seventy-five feet diameter circular tank having a liquid depth of ten feet six inches. The detention period at design flow of 4 MGD is 1.73 hours. With the present average daily flow, the size of the tank is quite adequate. At flows over 3 MGD, it has been observed that sewage cannot escape from the launder fast enough and when the flows reach 4 MGD the launders become submerged.

Normally, with detention periods of one to two hours, primary sedimentation tanks can remove up to fifty percent of the influent suspended solids. Raw sewage entering the Waterloo plant is high in suspended solids and even higher in BOD. Where only population data is available, acceptable equivalents for design are 0.20 lb. of suspended solids per capita per day and 0.17 lb. of BOD per capita per day which at 100 gallons per person per day gives suspended solids of 200 ppm and a BOD of 170 ppm. In the original design of the plant the S.S. of the raw sewage was considered as 270 ppm and the BOD 300 ppm which indicates that a

relatively strong sewage was expected.

From the above figures, it is seen that in a normal domestic sewage the BOD and S.S. are roughly of the same magnitude and that when a large proportion of S.S., i.e. 50 percent is removed a substantial amount of BOD (30%) is removed along with it. In the particular case of the Waterloo plant, the BOD to S.S. ratio is approximately 1.5 which indicates that a lot of the BOD is in a soluble form and therefore extremely hard to remove in a sedimentation tank.

Basically, it is poor sanitary engineering practice to have only one sedimentation tank in a sewage plant of this size because a failure of the unit completely disrupts the treatment process. It is normal practice to inspect the underwater mechanisms at least every two years to make any necessary repairs. There is also the possibility of having to dewater a tank because of some object dropping into the tank which might plug the sludge line.

The underwater parts of the mechanism in the existing primary tank at Waterloo are in extremely poor condition and may break down at any time. It will, therefore, be necessary to bypass the primary tank sometime in the near future. Whenever the tank is bypassed, all of the flow with its high BOD and S.S. load will have to be run directly into the aeration tanks where it may cause a septic condition or it may be bypassed through both final tanks where primary treatment can be given.

Many of the difficulties encountered in the primary section of the plant can be traced back to the malfunctioning of the

skiphoist. Whenever the skiphoist broke down the volume of the sludge in the bottom of the primary tank built up at an alarming rate. The only alternative possible at that time was to pump raw sludge to the digesters, which we were trying to empty or to haul raw sludge away in a tank truck. Due to the large volume of solids settling out, the tank truck could not keep up and the depth of sludge increased.

The excessive depth of sludge in the bottom of the tank exerts a very strong oxygen demand and turns the whole contents of the tank septic. When this septic liquid flows into the aeration tank, it upsets the process and a lot of air is used to return the liquid to an aerobic state.

It must also be pointed out that if the digesters in the plant are reconditioned, it will be necessary to withdraw the supernatant to the primary tank. Supernatant liquor is generally offensive in odour, high in suspended solids (500 to 1,000 ppm) total solids (1,000 to 12,000 ppm) and in BOD sometimes 1,800 ppm. The addition of supernatant will therefore have an injurious effect on the existing primary tank. Tests run on the effect of returning supernatant to sedimentation tanks in Toledo, Ohio showed that the BOD removal was reduced from 42.5 percent to 33.9 percent and the S.S. removal was reduced from 61.5 percent to 54.9 percent.

Another effect of the high sludge blanket in the bottom of the primary tank is the reduction in effective volume and, therefore, a reduction in detention time. For extensive periods of time six feet of sludge has been found in the bottom of the tank. This excessive depth effectively reduces the detention time to less than one half.

The waste activated sludge from the final tanks is wasted into the primary tank in the center well. This waste sludge is extremely light and hard to settle because of the bulking condition in the plant. It has been found that a majority of the waste sludge does not settle and passes back over the effluent weirs to the aeration tanks.

PART C -

CHLORINATION

Contemporary chlorination practices involve the application of chlorine at specific points where it will benefit the treatment process. The selection of points of application should be carefully selected in order to provide flexibility of operation.

Pre-Chlorination

Pre-chlorination is the addition of chlorine at the entrance to the plant. In addition to its application for disinfection and odour control, pre-chlorination is applied to reduce plant load (septicity and BOD) and as an aid to settling. Pre-chlorination of a raw sewage for a reduction in BOD is not normally practiced because the large amounts of chlorine required make it impractical.

Overloading due to shock loads may be partially reduced by intelligent use of pre-chlorination at the Waterloo plant. Pre-chlorination on a temporary basis was initiated in an attempt to improve the settling in the primary tank, but no improvement was noted due to the excessive sludge blanket in the bottom of the tank at the time.

As soon as conditions at the plant permit, pre-chlorination will again be attempted. Due to the extreme BOD fluctuations present at the Waterloo plant, it probably will be necessary to incorporate pre-chlorination facilities.

Plant Chlorination

Plant chlorination is the addition of chlorine to the sewage during or between other treatment processes. Chlorination of the return activated sludge prior to mixing of the sludge with effluent from the primary settling tank is presently employed to control bulking of the activated sludge. Chlorination at this point is most useful in controlling occasional bulking conditions. Since activated sludge bulking is a continuous occurrence at the Waterloo plant, the advantages of chlorination are not easily noted. From operating experience, it appears that the process was slightly improved while chlorinating.

Post-chlorination

Post-chlorination is the addition of chlorine following the treatment process. Post-chlorination is used for disinfection of the final effluent. In some instances, amounts of chlorine larger than those required for disinfection are used to reduce the BOD load on the receiving stream. Chlorination of the final effluent has not been practiced to date because of the primary sewage effluents presently entering the Grant River.

PART D -

AERATION TANKS

In the original design of the aeration tanks, it was assumed

that the primary tank would remove only 25 percent of the incoming BOD rather than a more normal 35 percent. The sampling results over the past year have proven that there is in fact no BOD removal in the primary tank and in some months a substantial increase in BOD as it passes through.

The original design of the aeration tanks was made on the assumption that the flow was 4 MGD, the raw sewage had a BOD of 300 ppm and the primary tank removed 25 percent of the incoming BOD. Thus, the total BOD load on which the aeration section was designed was 9,000 lbs. per day.

Four aeration tanks were provided, each tank being 135 feet long and 30 feet wide and a 15 foot liquid depth. These tanks provide a volume of 240,000 cu. ft. or 1,495,000 gallons. The detention time at 4 MGD flow is 9 hours with sewage only and 7.2 hours with 25 percent return sludge.

Over the period from February to September, 1961, the BOD to the aeration tanks had averaged 674 ppm and the average daily flow was 1.8 MGD. Therefore, during this period, the average daily BOD loading was 12,000 lbs. compared with the design loading of 9,000 lbs.

In the following paragraphs, an analysis is made of the various loadings which can be anticipated under certain conditions as well as a discussion of air requirements and blower capacities.

In the origianl design, it was assumed that 600 cu. ft. of air was required for each pound of BOD removed and an air blower with a capacity of 3,750 cu. ft. was provided along with a stand-

by blower of the same capacity thus giving a total blower capacity of 200 percent.

PRIMARY SEDIMENTATION TANK SAMPLE RESULTS 1961

	AVERAGE B.O.D.			AVERAGE S.S.		
MONTH	INF.	EFF.	% RED.	INF.	EFF.	% RED.
JAN.	632	610	3.5	341	326	
FEB.	730	1,227	+	400	2,120	+
MAR.	617	920	+	475	1,239	+
APR.	582	627	+	265	813	+
MAY	487	565	+	195	248	+
JUNE	622	571	8.2	425	357	
JULY	690	515	25.4	1,100	403	
AUG.	528	498	5.7	295	632	+
SEPT.	537	537	0	228	626	+
OCT.						
NOV.						
DEC.						

The FSIWA Manual of Practice No. 8 states:

"Air requirements vary with the design of aeration tanks and the method of air introduction. However, the air introduced is generally about 500 to 700 cu. ft. per pound of BOD removed, as long as the loading is not less than

about 30 lbs. of BOD per 100 lbs. of sludge solids. At lower BOD to solids loadings, endogenous respiration and nitrification increase air requirements tremendously. As much as 1,200 to 1,800 cu. ft. of air may be required per pound of 5 day BOD removed."

One questionable point in the original design was the fact that the figure of 600 cu. ft. of air was taken to handle each pound of BOD removed. Although this figure is acceptable according to the Manual of Practice, it leaves very little flexibility in operation for the operator. The installation of "Spargers" in the aeration system would also tend to increase the amount of air required. "Spargers" have the advantage of not needing extensive air filtering equipment and also cut down on diffuser plugging but they are a little less efficient in transferring oxygen to the sewage. A more practical figure to use for quantity of air supplied considering the above points might be 850 cu. ft. per lb. of BOD removed. This figure is the average air used in 29 conventional plants in the U.S. as reported in the September, 1961 Journal of Water Pollution Control Federation.

AIR REQUIREMENTS

Condition	BOD of Primary Effluent	Flow	Total Daily Loading	Cu. ft. of Air per lb. BOD Removed	Percent of Required blower Capacity provided
1.	225	4.0	9,000	600	200 %
2.	674	1.8	12,100	600	145
3.	674	1.8	12,100	850	102
4.	674	4.0	22,200	850	46
5.	390	1.8	7,000	850	182
6.	390	4.0	15,600	850	82

Discussion

Condition 1. - This is original design conditions of the consultant and need no future comment.

Condition 2. - This assumes loadings which are now being handled at the plant and a theoretical quantity of 600 cu. ft. of air. It is possible that in a normal heavily loaded sewage plant that the blowers would be quite adequate to handle the loading with a 45% standby.

This condition points up the fact that although the Waterloo plant has a heavy BOD load, it should still be able to handle the load. The reason why it cannot handle the load is that the shock discharges of BOD, pH variation and the nutrient deficiency

- damages the biological floc. The plant bacteria are just not able to utilize the oxygen being provided.

Condition 3 - This condition takes the more practical air usage of 850 cu. ft. and points out again that the Waterloo aeration tanks and blower system should be able to handle the BOD load although the standby blower capacity is far below any design requirements.

Condition 4 - This condition assumes that we have the present BOD in the primary effluent and that the plant flow has risen to design capacity, i.e. 4 MGD. It is obvious that with only 46 percent of the required blower capacity available that a plant cannot possibly operate even under the most ideal conditions. The solution to the problem is to lower the BOD of the primary effluent or to add more blower capacity.

Condition 5 - This condition assumes that primary sedimentation capacity is sufficient to provide a 35 percent reduction of BOD to the present raw sewage coming into the plant. If we had such primary treatment, and the other problems of nutrient deficiencies, pH variation and shock loadings were solved, the present blower capacity and aeration capacity would be quite sufficient for the present time.

Condition 6 - This condition assumes that the BOD loading and primary removal are the same as in Condition 5. but

- that the flow has risen to 4.0 MGD. Again, as in Condition 4., it is obvious that with only 82 percent of the required blower capacity the plant cannot possibly operate even under the most ideal conditions. Again the only solution to the problem is to lower the BOD or to add more blower capacity.

Looking over the general aeration problem at Waterloo, two things are very obvious:

1. The BOD of the raw sewage coming into the plant will always be very high because of the industrial wastes. Because most of this BOD is in a soluble form, it will be very hard for the industries to bring the BOD of their sewages within domestic limits without putting in their own biological treatment works. What the industry can do in regard to its BOD problem is to eliminate the shock BOD loads by evening out the fluctuations from the plants.
2. Assuming that the shock loads of BOD are eliminated, the Waterloo plant should provide the primary capacity to reduce the BOD loading to the aeration tanks. In time, as the flow of sewage to the plant increases, it will be necessary to increase the blower capacity and probably the size of the aeration tanks. At the present time, the BOD/SS ratio in the aeration tanks has been maintained within the proper limits as much as possible. Loading beyond these limits has occurred when the primary tank has bulked and

excessive solids and BOD have been admitted to the aeration section. Loading under the limits was purposely tried in an attempt to raise the dissolved oxygen level in the tanks but this was unsuccessful.

The failure of the aeration system at the Waterloo plant to adequately handle the high BOD loading is mainly due to shock loads of BOD and SS which would completely upset a plant of even larger capacity. It is essential that these extreme fluctuations be entirely eliminated. The other cause of upset and inefficient treatment is the extreme variation in pH in the raw sewage which inhibits biological activity. A normal domestic sewage is slightly alkaline (pH 7.1 - 7.3) and the activated sludge bacteria are normally conditioned to this small range of pH. It has been found that the activated sludge process can operate without diminution in efficiency at pH values in the feed of as high as 9.8. It has also been found that the buffering action of the sludge protects the system from surges of influent having a pH in excess of 10. The conditions at the Waterloo plant cannot, however, be considered as normal; the activated sludge has never been in a healthy condition and it is doubtful whether the Waterloo sludge can buffer the pH fluctuations as effectively as a normal sludge.

The one obvious conclusion is that the plant cannot tolerate the extreme fluctuations in pH. As in the case of

the BOD load, it is the fluctuations that are upsetting the process not just the presence of BOD and high or low pH. It is also clear that the industries are responsible for these fluctuations.

PART E -

EXISTING DIGESTERS

The existing digesters were constructed in 1948 as part of the original primary treatment plant. Both the primary and the secondary digesters are 50 feet in diameter with a 20 ft. SWD having a combined capacity of 78,600 cubic feet or 490,000 gallons. The primary digester is equipped with a mechanical stirring mechanism and the secondary digester has a floating cover. Both the primary and secondary covers are made of steel. Due to the character of the raw sludge and limited maintenance, the mixing mechanism deteriorated very badly and was of little value. Halfway through the construction of the plant extension, the city requested the consultants to consider replacing the mixer mechanism. In the design of the plant extension, no consideration had been given to the renovation of the existing digesters and, therefore, the money required was not included in the contract price. The cost of completely rehabilitating both units was estimated at $50,000. This extra expenditure would have exceeded the amount approved by the O.M.B. so as an alternative the consultants suggested that the feasibility of vacuum filtration of raw sludge be considered.

The vacuum filtration of raw sludge is an established practice in the U.S. and it eliminates the need for sludge digesters. This method of sludge treatment was accepted by the Local Advisory Committee with the understanding that if the experiment was not successful, the original proposal of digester renovation would be followed.

Since the vacuum filtration of raw sludge was not anticipated in the original design, the necessary piping changes had to be made in such a way that the layout was not the simplest nor the most efficient. Further minor piping changes have been made since the plant went into operation to provide more flexibility in sludge handling.

DIGESTER DESIGN

Three different design conditions are outlined below using the following general assumptions:

1. 95% removal of solids.
2. 70% volatile solids in sludge.
3. Required digester capacity at 60° F. = 17 cu. ft. per lb. of volatile solids per day.

At 95° F. required digester capacity = 0.45 x 17 = 7.65 cu.ft.

ORIGINAL DESIGN

- assume flow = 4.0 MGD
- assume suspended solids = 270 ppm.

$\therefore$ daily volatile solids load = 4.0 x 10 x 270 x 0.70 = 7175 lbs. per day.

Therefore required digester capacity = 7175 x 7.65 = 55,000 cu. ft.

PRESENT ACTUAL FLOW & S.S. LOADING

- assume flow = 2.0 MGD.

- assume suspended solids = 414 ppm.

Therefore daily volatile solids load = 2.0 x 10 x 414 x 0.95 x 0.70 = 5500 lbs. per day.

Therefore required digester capacity = 5500 x 7.65 = 42,100 cu. ft.

DESIGN FLOW & ACTUAL S.S. LOADING

- assume flow = 4.0 MGD

- assume suspended solids = 414 ppm.

Therefore daily volatile solids load = 4.0 x 10 x 414 x 0.95 x 0.70 = 11,000 lbs. per day.

Therefore required digester capacity = 11,000 x 7.65 = 84,200 cu. ft.

The existing digesters have a combined capacity of 78,600 cu. ft. From the above calculations, it can be seen that the existing digesters are theoretically capable of handling the suspended solids load at the plant.

PART F -

RAW SLUDGE FILTRATION

In the original plant design, the following assumptions were taken:

1. Plant flow 4.0 MGD.
2. Suspended solids 270 ppm.

3. Solids to be reduced 1/3 by digestion.

4. A 5 day @ $6\frac{1}{2}$ hours per day operation.

The digested sludge to be filtered equals 1473 lbs. per hour. Using the recommended filter rate of 5 lbs. per sq. ft. per hour, the required filter area equals 320 sq. ft. A 10 ft. x 10 ft. filter was provided which has an area of 314 sq. ft.

Since the suspended solids in the sewage have increased and sludge digestion is no longer practiced, we now have 1695 lbs. per hour to remove instead of the 1473 lbs. per hour anticipated in the design. This increase in sludge to be handled plus our inability to approach the filter rate of 5 lbs. per hour has forced us into a 7 day @ 14 hours per day operation.

In Table VIII the sludge filtering statistics at the Waterloo plant are listed. It can be seen that a gradual improvement in filtering has taken place. The average percentages of coagulants are being decreased and the average yield is increasing. The percentages of coagulants have been approaching normal figures for this type of sludge.

The FSIWA Manual of Practice No. 8 gives the following information for the vacuum filtration of raw primary and activated sludge:

Percent Ferric Chloride	Percent Lime	Filter Rate lbs/sq ft/hour
1.5 - 2.5	7 - 9	4 - 5

TABLE VIII

RAW SLUDGE FILTRATION

MONTH	TOTAL HRS. OF OPERATION	TOTAL LBS. DRY SOLIDS FILTERED	AVG. % LIME	AVG. % FERRIC CHLORIDE	AVG. YIELD LBS PER SQ. FT. PER HR.
JAN.					
FEB.	313	188340	22.4	5.7	1.9
MAR.	339	203266	14.9	8.0	1.9
APR.	167	91585	14.8	8.9	1.8
MAY	173	83599	22.9	17.2	1.6
JUNE	339	236000	15.6	8.3	2.2
JULY	178	159500	10.1	3.1	2.9
AUG.	305	269000	9.6	4.0	2.9
SEPT.	320	274100	10.0	4.2	2.8
OCT.	257	233700	8.5	3.4	3.0
NOV.	250	263638	7.1	3.1	3.4
DEC.	255	250285	12.2	4.8	3.3
TOTAL	2896	2253013			
AVG.	263	204819	13.5	6.4	2.5

The following is an analysis of the raw sludge filtration operation and its inherent problems:

1. More sludge is now handled at the plant than was originally anticipated in the design. This excess

amount is due to the heavy suspended solids load and the elimination of the digestion facilities. This increased sludge load would itself increase the hours of filtration.

2. Pickling liquor was used as a substitute for ferric chloride in the early part of the year. Pickling liquor is a waste product of the steel industry and laboratory experiments suggested that substantial savings could be obtained in using this material. The use of pickling liquor was discontinued when it was observed that the coagulant demand was increasing substantially and the filter rate was decreasing. Results from the Waterloo plant and two other OWRC plants also brought to light the fact that a large percentage of the solids going to the filter were also passing back out with the filtrate whenever pickling liquor was used. Under certain conditions, it was found that as high as 50% of the solids were being returned in the filtrates. The use of pickling liquor has been halted in all but one OWRC plant in light of this development.
3. A new timing gear was installed on the skiphoist in June of 1960 and the subsequent yield rates show a decided rise. Another timing gear was added in November which should increase still further the yield rate.

4. The malfunctioning of the skiphoist can be blamed for a large part of the sludge filtering difficulties at Waterloo. The speed of operation of the filter was limited by the speed of the skiphoist. The new timing gear improved the situation somewhat but it also increased the frequency of skiphoist breakdown. Whenever the skiphoist broke down, the sludge in the primary tank became more septic. Septic sludge is much harder to filter than fresh sludge and so whenever the filter could operate, it had to first filter all the septic sludge which had built up.
5. The efficiency of the vacuum filter is determined very closely by the percent of solids in the sludge pumped to the filter. Primary tank sludge is therefore much easier to filter than a mixture of primary sludge and waste activated sludge. The filtering at Waterloo is made more difficult because the waste activated sludge is bulking all the time and will not settle or filter as well as a normal waste activated sludge.
6. Increased alkalinity of the sludge going to the filter increases the required dosage of coagulants. The Waterloo sludge has a higher alkalinity because of the hardness of the city water supply and also because of the large amounts of caustic wastes discharged by the local industries. Vacuum filtration of sludge at Waterloo will therefore require higher than normal coagulant requirements.

SLUDGE FILTERING COSTS

PER TON OF DRY SOLIDS

MONTH	$FeCl_3$	Lime	Labour	Electricity	Maintenance	Total Cost Per Ton
FEB.	6.60	6.63	6.66	1.40	1.00	22.29
MAR.	8.85	4.48	6.66	1.40	1.00	22.39
APR.	10.70	4.84	7.30	1.40	1.00	25.24
MAY	19.10	6.71	8.25	1.40	1.00	36.46
JUNE	9.10	4.38	5.75	1.40	1.00	21.63
JULY	4.14	3.15	4.45	1.40	1.00	14.14
AUG.	5.11	3.05	4.52	1.40	1.00	15.08
SEPT.	5.73	3.13	4.67	1.40	1.00	15.93
OCT.	4.71	2.63	4.39	1.40	1.00	14.18
NOV.	4.25	2.35	3.79	1.40	1.00	12.79
DEC.	6.35	4.05	4.08	1.40	1.00	16.88
AVG.	7.70	4.10	5.50	1.40	1.00	19.70

A close evaluation of the amount of sludge to be handled will now be made.

Assuming the design flow of 4.0 MGD and the present plant loading of 414 ppm suspended solids, the amounts of sludge to be disposed of are:

Raw sludge   400 x 40 = 16,000 lbs.

Digested sludge (assuming 1/3 reduction in solids) = 10,700 lbs.

RAW SLUDGE FILTRATION

- assume ideal conditions

Chemical Dosage % by wt.		Filter Rate lbs. per hr.
$FeCl_3$	CaO	
1.5-2.5	7-9	4-5

Assume 2.5% ferric chloride, 9% lime and a filter rate of 5 lbs. per hour.

With 16,000 pounds of raw sludge, we would use:

a) $16{,}000 \times \frac{2.5}{100} = 400$ pounds ferric chloride

b) $16{,}000 \times \frac{9.0}{100} = 1400$ pounds lime

The required filtering time would be $\frac{16000}{300 \times 5} = 10.7$ hrs.

DIGESTED SLUDGE FILTRATION

- assume ideal conditions

Chemical Dosage % by wt.		Filter Rate lbs. per hr.
$FeCl_3$	CaO	
1.5-3.5	6-10	4-5

Assume 3.5% ferric chloride, 10% lime and a filter rate of 5 lbs. per hour.

With 10,700 pounds of digested sludge we would use:

a) $10700 \times \frac{3.5}{100} = 374$ pounds of ferric chloride.

b) $10700 \times \frac{10}{100} = 1070$ pounds of lime.

The required filtering time would be $\frac{10700}{300 \times 5}$ = 7.1 hours.

From the preceding calculations, it can be seen that when digested sludge is filtered the amounts of chemicals required and the required filtering time are reduced. Recent literature from the coil-filter manufacturer has suggested that raw sludge filtration costs are lower than digested sludge filtration, but we have no operating data to substantiate this contention.

RAW VS. DIGESTED

From the purely theorectical considerations outlined on the previous page, we would save 25 lbs. of ferric chloride, 300 lbs. of lime and 3½ hours of filtering time per ton of solids. The estimated average daily savings on 4 tons of solids per day would be:

Item	Quantity	Cost
Ferric chloride	25 lbs.	1.66
Lime	300 lbs.	3.30
Labour	3.5 hrs.	7.00
Power		3.50
Maintenance		4.00
		$19.46 per day

or $7,100.00 per year.

In addition to the savings in filtering costs by going to digestion, we can utilize digester gas for plant heating if the digesters are put back into operation. During a normal heating

season, approximately $1,300 of fuel oil is burned. Therefore, the total estimated annual saving using digestion would amount to $8,400.

According to compound interest tables, assuming a 5% interest rate, we could spend $ 105,000 now in renovating the existing digesters to save the $ 8,400 per year, assuming the renovations are good for 20 years.

An outline will now be given of the pros and cons of raw sludge filtration and then a general discussion of the situation as it applies to the Waterloo plant will be given.

ADVANTAGES OF RAW SLUDGE FILTRATION

The vacuum filter manufacturer presents these general arguments for fresh solids dewatering:

1. Higher filter yields and decreased chemical dosages are due to the more fibrous nature of the raw sludge.
2. The lime used in conditioning the sludge neutralizes the acidic constituents that give rise to the odour nuisances that might result from the handling of fresh sludge. Lime introduced prior to exposure of the sludge to the atmosphere eliminates odour nuisances even with septic sludges.
3. The suitability of fresh sludge as a culture media for the growth and survival of bacteria, etc., will be altered by virtue of the coagulating effect of the ferric chloride, and by the establishment of a highly alkaline environment that is a deterrent to the survival of pathogenic organisms.

4. The capital costs of digesters are eliminated. This is a very substantial saving when the total design of a new plant is considered. This argument has less validity, however, in the case of Waterloo because we do have digesters and for a relatively small investment we can return these digesters to service.

ADVANTAGES OF FILTERING DIGESTED SLUDGE

1. From a bacteriological standpoint, raw sludge filter cake when limed to a high pH of 11 may be no more hazardous than digested sludge due to the bactericidal effects of caustic lime, but it has been found that other species of pathogens which will not survive digestion are not affected by lime.
2. Raw sludge is more odorous; its grease content is roughly four times as high as that of digested sludge thereby retarding assimilation into the soil. A number of states prohibit the application of raw sludge directly to the soil and the FSIWA went on record in 1946 in its Manual of Practice No. 2 as opposed to the use of raw primary sludge in any form as fertilizer.
3. Dewatering raw sludge may not prove as economical in the long run as might be expected. Digestion will reduce the solids to 30 to 40 percent so that the filter must have from 50 to 75 percent greater capacity for raw than digested sludge. Also, the raw sludge filter must

handle peak daily loads which can be 200 percent of the average. This is especially true in the case of the Waterloo plant. The digested sludge peak loads will usually not exceed 150 percent of the average. Combining these factors will result in a raw sludge filter capacity of twice that required for digested sludge.

4. Raw sludge dewatering facilities perferably should be in duplicate as delays due to breakdown of any equipment cannot be tolerated. When filtering raw sludge, a storage tank is needed to balance sludge production with filter operating time. When filtering digested sludge, delays of a few days for repairs are of less consequence as a digester is usually sufficiently flexible in capacity to tide over inoperative periods.
5. Variations in quality of raw sludge permit less day-to-day precision in chemical additions resulting in frequent overdosing. With a digested sludge, the changes in sludge quality are very small and very precise chemical additions can be made and the resulting chemical costs reduced. This feature is especially true of the Waterloo sludge because of the extreme variations in sludge quality.

PART G -

ULTIMATE DISPOSAL OF SLUDGE

With the present plant design, the ultimate disposal of sludge must be on the land. The nearest available sources of land are the

surrounding farm lands and the city dump. Other suitable dumping sites have been difficult to find.

DISPOSAL TO FARMLAND

Whenever possible, the raw filtered sludge has been trucked to farms adjacent to the plant. This method of disposal has the following limitations:

1. The close proximity of subdivisions limits the amount of raw sludge. If too much sludge is dumped, the odour becomes quite noticeable and complaints are received. Digestion of the sludge would reduce the ultimate volume and will also provide a much less odorous sludge.
2. Farmers' lands are not year-round dumping sites. Spring and fall rains make the ground too soft for the truck. Summer crops prevent any disposal during the summer months. Farmland is best suited for disposal when the ground is firm or the fields are lying fallow.
3. The Waterloo sludge has a lower fertilizer value than most sewage sludges and is therefore of less value to farmers. An intensive promotional program must be undertaken to develop a demand among the local farmers for this product.
4. Filtered sludge is not as convenient for farmers because it cannot be easily spread over the land. A sludge spreader for the dump truck at the plant was made up but met with very little success.

DISPOSAL TO CITY DUMP

Most of the filtered sludge has been trucked to the city dump for disposal. Various methods of handling the sludge have been tried.

a) Disposal in Large Pits and then Covered with Earth.

It was found that raw sludge did not give off its water content very easily and acted like a quicksand when piled very deep. The earth fill deposited on top of the sludge quickly sank to the bottom of the pit and the sludge rose to the top. It was also dangerous for the dump truck to back up too close to the edge of the pit. This method has been proven to be totally unsatisfactory.

b) Disposal by Spreading on Top of the Ground.

The raw sludge does not readily dry when spread over the ground and it also gave off very obnoxious odours even when limed to a high degree. Digested sludge could be spread with much less difficulty because it would dry quite rapidly and would not give off much odour.

c) Disposal in Shallow Trenches and then Covered with Earth Within a Few Hours.

This method has proven to be the most satisfactory, but it entails expenses in digging the trenches and covering them with a layer of earth. This method also requires close liaison between the plant staff, the city engineer and the dump operator.

The city dump is the best disposal area for the following reasons:

1. Trucking time is cut to the absolute minimum because the dump is so close. The close proximity saves plant labour, truck maintenance expenses and filter delays.
2. The truck does not have to pass through any built-up areas. The trucking of sludge through built-up areas is a possible source of complaints.
3. The dump is a year-round dumping site except for especially poor weather conditions. Machinery is also available to help the truck if it becomes stuck.

PART H - PLANT EQUIPMENT

All equipment in sewage plants gradually wears out. A good preventative maintenance program can effectively reduce this aging process to a minimum and ensure that no interruption of the treatment process takes place.

The existing equipment at the Waterloo plant at the time of OWRC takeover was in extremely bad condition. This was due to the character of the raw sewage and the lack of a good preventative maintenance program. The following equipment was in the original plant and has been repaired since OWRC takeover or is still awaiting repair.

1. Sewage Flow Meter

The sewage flow meter had deteriorated very badly because of the extremely corrosive atmosphere in the detritor building. It was obvious from the condition of all the mechanical and electrical equipment in this building that the character of the raw sewage and the lack of maintenance had prematurely deteriorated the equipment. The flow meter was removed and completely reconditioned by the manufacturer. The electrical equipment will have to be replaced in the near future.

2. Grit Rake

The grit rake located in the detritor room had some badly worn parts and these were replaced.

3. Primary Sedimentation Tank

The existing primary sedimentation tank is in very poor condition. An attempt was made to repair this unit in June of 1960. The tank was dewatered and cleaned but before the structural steelwork could be repaired, sandblasted or painted, the aeration section went septic and the tank had to be returned to service.

Since that time, we have been unable to remove the tank from service. It is anticipated that the structural steel will fail and it will be necessary to bypass the raw sewage into the aeration section.

The condition of the primary tank is due to three main factors:

a) It is impossible to remove the tank from service without completely disrupting the process because there is only one tank. With the old primary tank, the whole plant would have had to be bypassed and with the present plant, a severe load will be put on the aeration section.

b) The corrosive character of the raw sewage is the principal cause of the premature damage to the underwater structural steel.

c) Past preventative maintenance has been at a minimum.

4. Primary and Secondary Digesters

Both digesters and the associated piping and equipment are in very poor condition. The mixer mechanism had broken down, the piping was either plugged or corroded and the boiler was extremely corroded and was scrapped in the new addition.

The following equipment has been installed in the new plant and has required varying degrees of attention:

a) Raw Sludge Pump

The new raw sludge pump has been used far in excess of its normal operating time due to the large quantities of sludge to be handled. The piston of the pump has had to be machined and the wristpin replaced. This is due to long hours of operation and the necessity of pumping gritty sludge from the old digesters. The corrosive character of the raw sludge caused the surge

chamber on this pump to develop leaks and a new chamber had to be made. Under normal conditions, a surge chamber will last approximately 10 years.

b) Skiphoist

The troubles experienced with the skiphoist since the startup of the plant have influenced the total operation of the plant. The manufacturers of the skiphoist were called upon many times to remedy the defects in the equipment. Many changes were made in the design but the mechanism continued to break down under the constant operation. In all fairness to the manufacturer, it must be pointed out that because of the extremely large quantities of sludge to be removed, the skiphoist had to be operated all the time that the operators were on duty and, consequently, preventative maintenance was of necessity at a minimum.

When it became apparent that the skiphoist as designed would never stand up to the job, the manufacturer was told that the mechanism was unsatisfactory to the Commission and that a completely new design must be made. The manufacturer, at conderable cost, did design and install a complete new skiphoist which was deemed satisfactory to the Commission. Some initial difficulties were also

encountered in the redesigned skiphoist. The limit switches broke and the shafting showed undue wear. These difficulties were soon solved and it appears that the skiphoist is now satisfactory and will perform as required.

The interval between the first skiphoist and the installation of the final mechanism has of necessity been a long one. The installation was tried out in service and when a change or repair was needed it was made. It was very difficult to prove that the original skiphoist was totally unsatisfactory. The machine did perform the function it was designed for, but it just would not last. Determination of the period of endurance of a machine is a very time consuming process.

c) Air Blowers

Both air blowers have to be operated 24 hours per day, 7 days a week and cannot be taken out of service for more than a few hours without turning the aeration tanks septic. It is essential that standby blower capacity be provided before a serious breakdown occurs. Standby capacity may be provided in two ways:

i) Reduction of the BOD load on the aeration section will decrease the amount of air required and will have the effect of increasing blower capacity.

ii) An additional blower with a capacity of 3750 cu. ft. per minute would provide standby capacity in case one of the regular blowers had to be shut down. The cost of the blower would be approximately $14,000.

d) Air Check Valves

The intense vibration from the air blowers completely destroyed the original check valves. The supplier contacted another manufacturer and two new check valves were installed. These check valves have not been satisfactory and the manufacturer is supplying an improved model.

Although the noise from the blowers is an inconvenience for the plant staff, it is not an operating problem. When the new air check valves are installed, a flexible coupling will be put in the line to try and reduce the noise level. The air intakes have already been moved to above the roof of the control house and a reduction in noise around the plant grounds was noted.

An additional problem in the blower room has been the build up of heat. This heat causes the electrical heaters to trip out. The doors to the blower room are left open in an attempt to cool the room and this causes the noise level around the plant to increase.

e) Vacuum Pump and Filtrate Pump

The hard water from the plant well has caused a scale build up on the water seals of the vacuum pump and the filtrate pump. The vacuum pump has been dismantled mantled many times in the past year and the scale chipped away. At present, two water softeners are used to attempt to reduce the frequency of plugging and this has helped considerably. A design for a completely closed water seal system for the vacuum pump has been made and can be incorporated if required.

f) Sludge Filter

The long filtering hours required to handle the large amount of sludge has created some minor difficulties with the sludge filter. The preventative maintenance, clean-up and painting has been at a minimum and as oon as the filter can be shut down for a few days, the entire filter should be repainted.

The extremely hard water from the well combined with the lime used in the process has caused a build up of scale on the drum, vat, coil springs and piping. This scale has ruined the clean appearance of the drum, decreased the internal diameter of the piping and filled the spaces between the coils of the filter medium which increases their effective length and causes them to sag.

To combat this liming-up problem, large quantities of muriatic acid and recently an inhibited muriactic acid called "Oakite" have been used. A complete cleaning using "Oakite" will cost $300 and it is anticipated that this will be a yearly expenditure.

g) Chemical Pumps

Due to the large quantities of sludge to be filtered, the chemical pumps for the sludge filter have been operated at excessive pumping rates for extended periods. A large number of diaphragms have ruptured under this constant loading and sprayed the very corrosive chemical over themselves and surrounding equipment.

PART I -

INFLUENT TRUNK SEWER

The existing influent trunk sewer to the plant has been observed leaking at a number of points. This leakage now runs into Laurel Creek.

OLD PLANT BUILDINGS

In modern sewage treatment plant design, adequate staff facilities are considered a very necessary and important feature. Adequate staff facilities improve staff morale and induce the staff to maintain themselves and the rest of the plant in a neat and clean condition.

In the original design, adequate staff facilities were eliminated for economic reasons and in this appraisal of the plant, they should now be provided as follows:

a) Adequate locker room and lunch room facilities.

b) Office for the Chief Operator.

c) Proper toilet and shower facilities.

SLUDGE BEDS

During construction of the plant, sludge holding beds were created on the land at the rear of the old building. This land is part of a farm belonging to Mr. Snider and was used with his permission subject to the condition that they would be removed as soon as the plant was finished.

During 1961, Mr. Snider made repeated requests that the beds be removed and the fence be replaced. After an unsuccessful attempt to remove the sludge and truck it to the city dump, it was decided to spread the sludge in a thin layer over the whole field with a bulldozer so that the sludge would dry faster. The cost of spreading these beds was $1700 and during the winter a bulldozer or grader will have to be hired to finish levelling the land. After the land is graded, a new fence must be provided along the property boundary.

SURROUNDING AREA

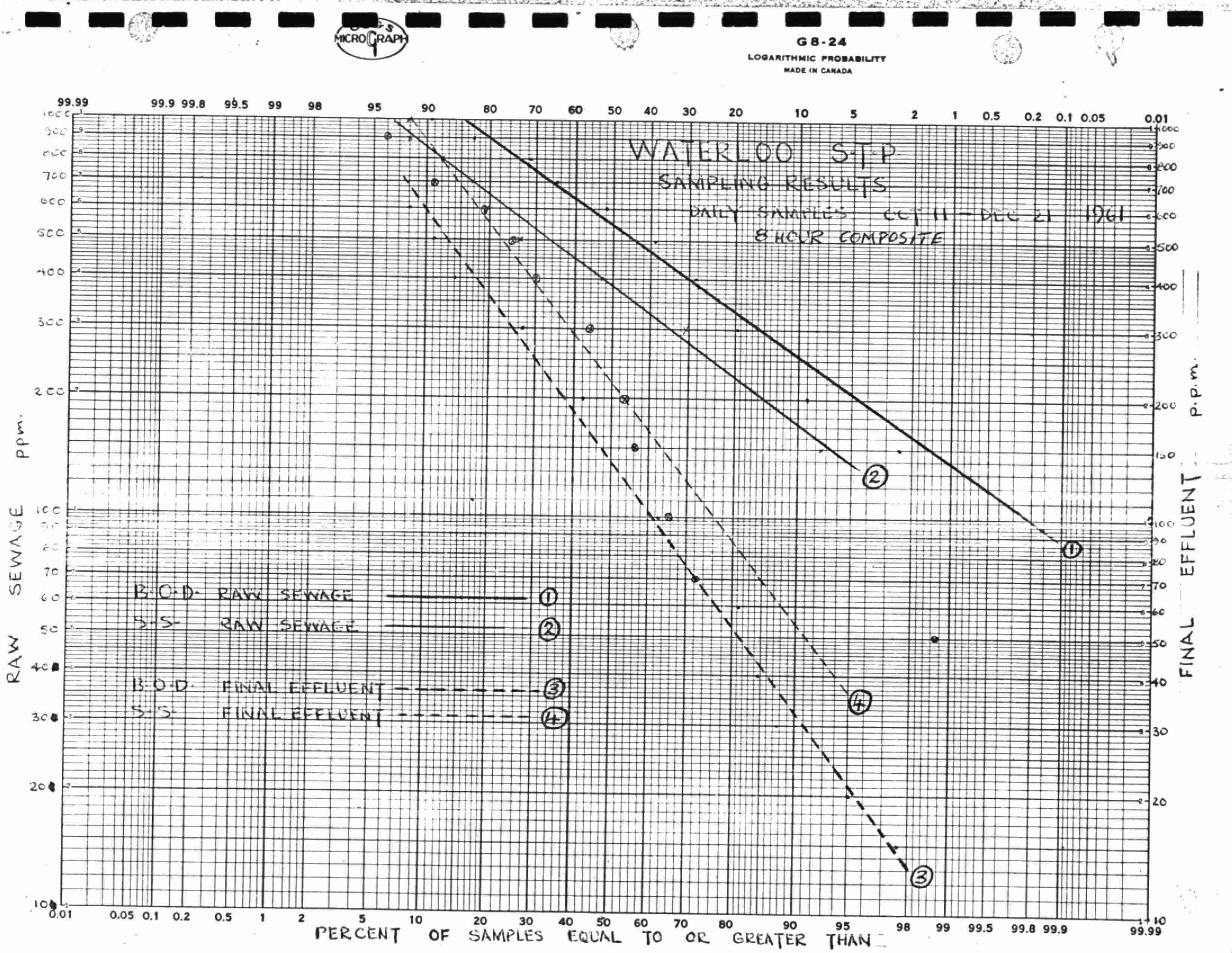
The Operations Division has been concerned for some months with the continual advance of subdivisions toward the treatment plant grounds. Development of lands immediately adjacent to the

plant site should be discouraged and a buffer strip created around the plant.

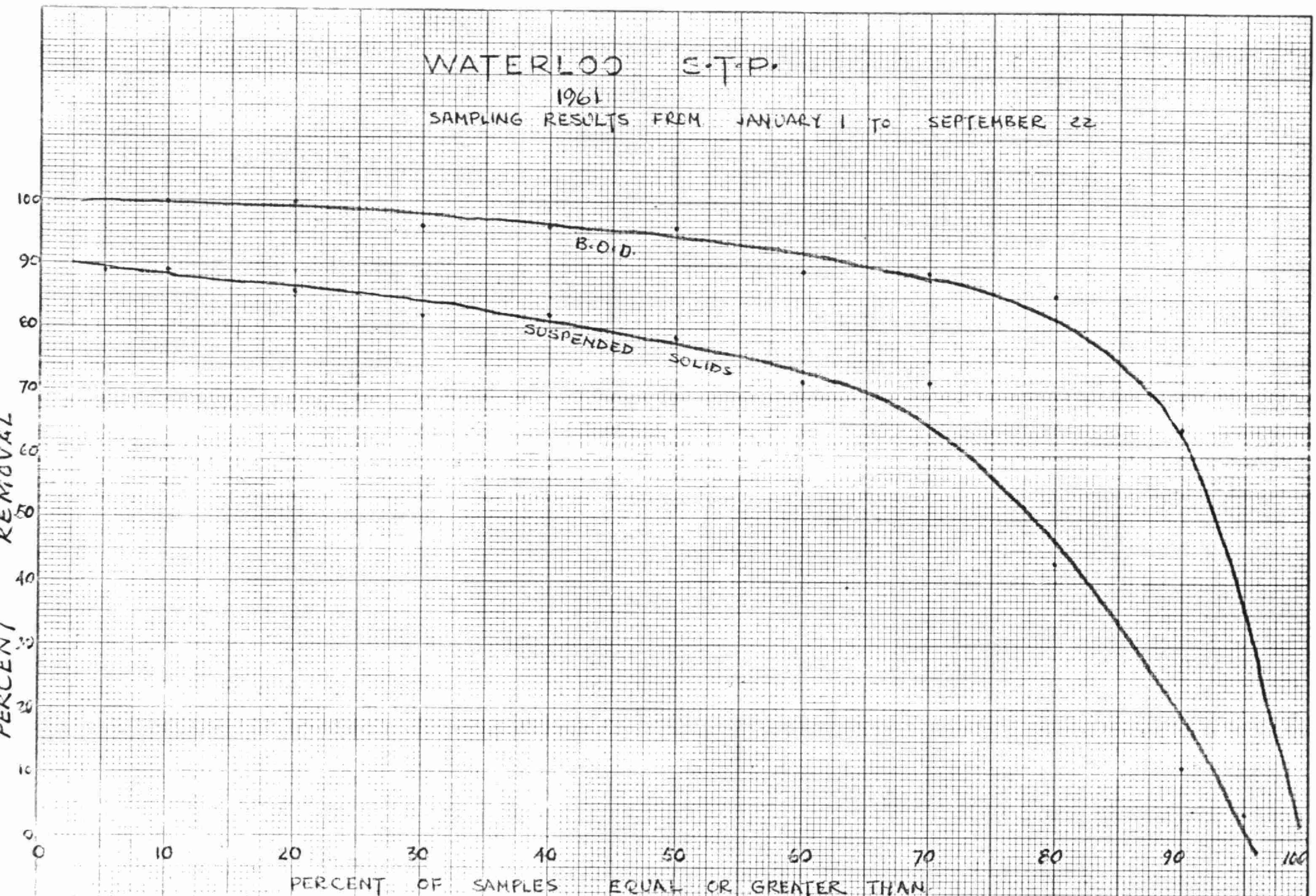
As the plant site becomes surrounded with homes, the danger of persons, especially children, trespassing on the plant grounds becomes more acute. In order to completely protect both the plant and the public, it is recommended that a fence be provided around the complete plant.

It is suggested that a farm type fence with barbed wire along the top would provide sufficient protection. The total length of fence required to enclose all of the tanks and buildings is 2330 feet and the cost of fencing would be approximately $1000.

It will also be advisable to maintain the grounds immediately outside the fenced area in order to present an attractive setting for the plant. As adjacent lands are developed, the amount of landscaping around the plant should also be increased to avoid any criticism in this respect from the neighbours.



G8-24
LOGARITHMIC PROBABILITY
MADE IN CANADA
WATERLOO S.T.P.
SAMPLING RESULTS
DAILY SAMPLES OCT 11 - DEC 21 1961
8 HOUR COMPOSITE
B.O.D. RAW SEWAGE ①
S.S. RAW SEWAGE ②
B.O.D. FINAL EFFLUENT ③
S.S. FINAL EFFLUENT ④
RAW SEWAGE ppm.
FINAL EFFLUENT p.p.m.
PERCENT OF SAMPLES EQUAL TO OR GREATER THAN



WATERLOO S.T.P.
1961
SAMPLING RESULTS FROM JANUARY 1 TO SEPTEMBER 22
B.O.D.
SUSPENDED SOLIDS
PERCENT REMOVAL
PERCENT OF SAMPLES EQUAL OR GREATER THAN
0
10
20
30
40
50
60
70
80
90
100

Date Due

MAY 25 1970			
DEC 27 1974			